10. On the Variation of the Scapula in the Batrachian Groups Aglossa and Arcifera. By Joan B. Procter, F.Z.S.

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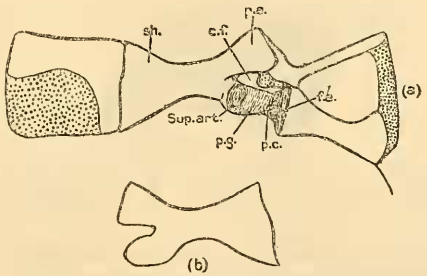
(Text-figures 1–10.)

The variation of the scapula in the Batrachia Ecaudata is of considerable interest, both on account of its wide range and of its comparative stability within a genus. The present study has been confined to the Aglossa and the Arcifera as representing the most primitive types now living. I have examined all the skeletons in the collection of the British Museum, but this material, although large, is not as complete as one could wish.

Text-figure 1.



Bufo hæmatiticus. ×2.

(*a*) Pectoral girdle from without; (*b*) scapula from within.

p.a., *pars acromialis.* p.g., *pars glenoidalis.* sh., *shaft.* sup.art., *superficial articulation.* f.a., *fovea acetabulum.* c.f., *central foramen.* p.c., *paraglenoid cartilage.*

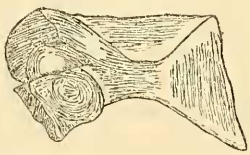
In the majority of species the scapula is about equal to the præcoracoid in length; it is usually rather slender in the middle and expanded at each end. The proximal end consists of two parts, generally separated by a cleft: the upper or *pars acromialis* is either in contact with the head of the præcoracoid, or narrowly separated from it by *acromion cartilage*; the lower or *pars glenoidalis* is much depressed and concave, forming the bottom of the glenoid cavity—it may be in contact with the end of the coracoid, or separated from it by *paraglenoid cartilage.* This cartilage also forms a subtriangular knob projecting below the head of the præcoracoid, and attached to the head of the humerus by a ligament. The portion of the scapula between the glenoid cavity

and the supra-scapula will be alluded to as the *shaft*. A circular depression is often situated in the thickness of the shaft, where it becomes one with the *pars glenoidalis*: it is called the *superficial articulation*, and forms the distal wall of the glenoid cavity; opposite to it is the *fovea acetabulum*, a similar depression in the *extremitas scapularis* of the coracoid, which forms the proximal wall of the glenoid cavity.

In order that the varying proportions in the different genera may be fully appreciated, the length of the præcoracoid will always be given as 10 units*, and all other measurements standardized to this scale; in this way the comparative reduction and development can be seen at a glance, as the normal length of the scapula should be about 10 also.

In fossil frogs of the genus *Palæobatrachus*, the scapula was shorter and more compact than in the majority of modern genera, being three- to four-fifths the length of the præcoracoid, and about once and a half as long as broad at its expanded end. The *pars*

Text-figure 2.



Scapula of *Palæobatrachus* sp.? ×2. (After Wolterstorff.)

acromialis was not distinct from the *pars glenoidalis*, but, according to Wolterstorff, a groove can be seen on the inner surface of the bone, in place of the cleft shown by modern forms.

The following figures are standardized from actual measurements given by Wolterstorff †.

Examples.

	P. fritschii.		*P. grandipes.*	*P. wetzleri.*
Length of præcoracoid ...	10	10	10	10
,, scapula	6	6·4	7·3	8·5
Breadth of ,, (proximal)	3	3·6	4·5	5·7
,, ,, (distal) ...	4	4·5	5·5	6·7

Although the size of the scapula varies in comparison with the præcoracoid, its own proportions are remarkably stable. Wolterstorff says of it‡: "Es finden sich nur wenige vielleicht nicht einmal specifische Verschiedenheiten."

* Units of length.

† 'Ueber fossile Frösche, insbesondere das Genus *Palæobatrachus*' (Theil i. 1886; Theil ii. 1887).

‡ *Op. cit.*

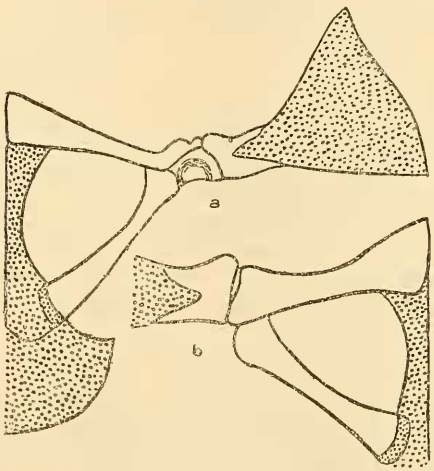
Pipidæ.

As in *Palæobratrachus*, the genera of this family have the scapula entire, without the cleft which separates the *pars acromialis* from the *pars glenoidalis*, at least partially, in all other families. This, together with the marked reduction of the scapula, constitute diagnostic characters for the Pipidæ.

Xenopus Wagl.

X. lævis Daud.—Scapula vestigial; subtriangular. Shaft and *pars acromialis* completely absent; *pars glenoidalis* containing the circular depression of the glenoid cavity. Head of præcoracoid in contact with supra-scapula. Occasionally the scapula is

Text-figure 3.



Pectoral girdle of *Xenopus lævis*. ×2.

(*a*) scapula distinct; from without.
(*b*) scapula not distinct; from within.

apparently wanting, having fused with the head of the præcoracoid; in most specimens this fusion is more or less marked, making the boundaries of the vestigial scapula difficult to trace.

Example.

Length of præcoracoid	10 units.
,, scapula (at base)	2·4 ,,
Breadth of ,, (expanded end)	2·1 ,,
Length of supra-scapula	10·3 ,,

X. muelleri Ptrs.—Scapula as in *X. lævis*. A figure of the pectoral girdle is given by Peters*, in which it is absent. In

* Peters, 'Reise nach Mossambique' (1882) Taf. xxvi. 12 *a*.

his specimen it is evidently incorporated in the præcoracoid, as described above.

X. calcaratus Buchh. & Ptrs.—Scapula as in *X. lævis*, but more easily distinguished, as the glenoid cavity extends to the upper border.

X. clivii Peracca.—Scapula with a distinct, but vestigial, triangular shaft, the apex of which narrowly separates the head of the præcoracoid from the supra-scapula; *pars glenoidalis* as in *X. lævis*; *pars acromialis* absent.

Example.

Length of præcoracoid	10	units.
,, scapula (at base)	3·3	,,
,, ,, (upper edge)	·55	,,
,, ,, shaft	1·7	,,
Breadth of ,, (expanded end)	2·8	,,
Length of supra-scapula	9·4	,,

In the tadpoles and young of *X. lævis*, *X. calcaratus*, and *X. muelleri* the reduced condition of the scapula is somewhat less marked than in the adults; an extremely short shaft is present, precisely as in the adult of *X. clivii*. If ontogeny may be taken as a guide to phylogeny, *X. clivii* should be considered the most primitive species in the genus.

This vestigial form of scapula, which even in *X. clivii* does not exceed two-fifths of the præcoracoid in length, and which may be completely suppressed in other species, renders *Xenopus* unique both among the Aglossa and Arcifera.

Hymenochirus Blgr.

H. boettegeri Tornier.—Scapula much reduced, but less so than in *Xenopus*. Distal end expanded, proximal end narrowed, entire; the whole wedge-shaped. Proximal end strongly overlapped on outer surface by head of præcoracoid. No glenoid cavity.

Example.

Length of præcoracoid	10	units.
,, scapula (greatest)	5·5	,,
,, ,, (upper edge)	3·1	,,
Breadth of ,, (expanded end)	3·3	,,
,, ,, (least)	2·2	,,
Length of supra-scapula	8·9	,,

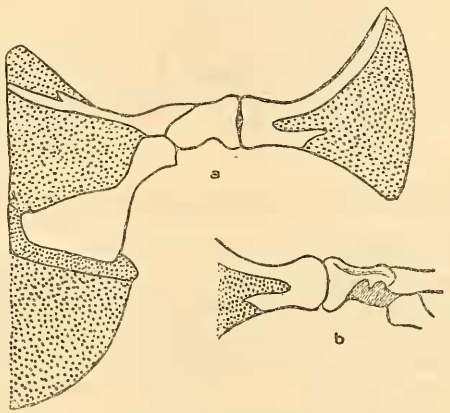
Pipa Laur.

P. americana Laur.—Scapula compact, very much reduced, almost triangular when seen from within. Shaft vestigial; *pars acromialis* strongly overlapped by head of præcoracoid on inner surface; a strong crest and protuberance on outer surface, bordering the glenoid cavity; *pars glenoidalis* much depresssed when seen from without, not distinct from *pars acromialis* when seen from within.

Example.

Length of præcoracoid	.....	10 units.
,, scapula	.....	3·9 ,,
,, ,, (free upper adge)	.....	1·9 ,,
,, ,, shaft	.....	1·1 ,,
Breadth of ,, (distal end)	.....	2·6 ,,
,, ,, (least)	.....	1·8 ,,
Length of supra-scapula	.....	9·2 ,,

Text-figure 4.



Pectoral girdle of *Pipa americana*. ×2.
(*a*) from within; (*b*) scapula from without.

Arcifera.

In all the Arciferous genera in which I have studied the scapula, its three main branches are all present, even if one or more of them is reduced. The *pars acromialis* is more or less separated from the *pars glenoidalis* by a cleft or foramen.

Discoglossidæ.

As in *Pipidæ* the scapula is greatly reduced. The *pars acromialis* more or less overlaps the *pars glenoidalis*, so that the cleft which separates them can only be seen when viewed obliquely.

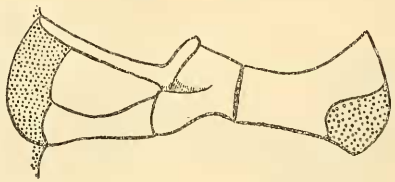
Discoglossus Otth.

D. pictus Otth.—Scapula much reduced, its greatest length only half that of the præcoracoid. Shaft vestigial; *pars acromialis* well developed, but shorter than *pars glenoidalis*; not overlapped by head of præcoracoid; *pars glenoidalis* well developed, strongly depressed, the separating cleft pierced horizontally. In eight skeletons of this species there appears to be no individual variations.

Example.

Length of præcoracoid	10 units.
„ scapula (lower border)	5 „
„ „ (free upper edge)	3·1 „
„ „ shaft	2·2 „
Breadth of „ (distal end)	3·5 „
Length of supra-scapula	9·4 „

Text-figure 5.



Pectoral girdle of *Discoglossus pictus*, ×2; from within.

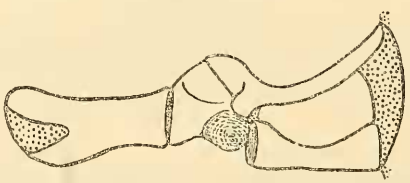
Bombinator Merr.

B. igneus Laur.—Scapula much reduced, subtriangular in shape; upper edge shorter than distal edge. Shaft vestigial; *pars acromialis* much reduced, forming an oblique suture with head of præcoracoid; *pars glenoidalis* much depressed, longer than *pars acromialis*, from which it is separated by a notch rather than by a cleft.

Example.

Length of præcoracoid	10 units.
„ scapula (lower border)	4·3 „
„ „ (upper „)	2·6 „
„ „ shaft	1·7 „
Breadth of „ (distal end)	3·2 „
Length of supra-scapula	9·1 „

Text-figure 6.



Pectoral girdle of *Bombinator maximus*, ×2; from without.

B. pachypus Blgr. and *B. orientalis* Blgr.—Scapula as in *B. igneus*.

B. maximus Blgr.—Scapula as in *B. igneus* in shape and proportions, but differing in that the upper border and adjoining

head of præcoracoid are thin almost to transparency, forming a semicircular crest, the diameter of which follows the free upper edge.

The proportions of the scapula are remarkably stable within the genus *Bombinator*, and are highly characteristic.

Alytes Wagl.

A. obstetricans Laur.—Scapula short, but less reduced than in *Discoglossus* and *Bombinator*. Upper border forming a semicircular crest thin to transparency, resembling *Bombinator maximus* in this respect. Shaft reduced; *pars acromialis* narrow, in contact with head of præcoracoid; *pars glenoidalis* broad, depressed, equal in length to *pars acromialis*; the two overlapping, so that the dividing cleft is pierced horizontally and only visible obliquely.

Example.

Length of præcoracoid	10	units.
,, scapula (lower edge)	4·3	,,
,, ,, (upper ,,)	3·6	,,
,, ,, shaft	2·2	,,
Breadth of ,, (distal end)	4·3	,,
Length of supra-scapula	10	,,

Pelobatidæ.

In this family there is a wider generic diversity in the proportions of the scapula, which is not, however, greatly developed in any genus. In all, the glenoid cavity is excessively deep, somewhat undermining the *pars acromialis*, the lower edge of which circumscribes it above.

Scaphiopus Holbr.

S. solitarius Holbr.—Scapula well developed, longer than præcoracoid; as long as the supra-scapula. Proximal end well developed, subcircular. Shaft long, wedge-shaped; *pars acromialis* large, with crest-like upper border, lower border projecting over and round glenoid cavity in a strong ridge; *pars glenoidalis* small, strongly depressed, the dividing cleft short and broad, forming a small oval foramen in the glenoid cavity, pierced vertically.

Example.

Length of præcoracoid	10	units.
,, scapula (upper or lower border)	13	,,
,, ,, shaft	9·4	,,
Breadth of ,, (distal end)	5·3	,,
,, ,, (middle)	2·5	,,
Length of supra-scapula	13	,,

Pelobates Wagl.

P. fuscus Laur.—Scapula well developed, thick, once and a half as long as præcoracoid. Shaft oblong, twice as long as broad; *pars acromialis* broad, the lower border of its outer surface with a ridge which runs round the glenoid cavity; *pars glenoidalis* much depressed; dividing cleft short, forming an oval foramen pierced horizontally.

Example.

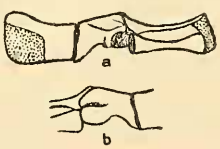
Length of præcoracoid	10 units.
,, scapula (lower edge)	15 ,,
,, ,, shaft	10·4 ,,
Breadth of ,, (distal end)	5 ,,
Length of supra-scapula (lower border)	15 ,,

P. cultripes Cuv.—Scapula precisely as in *P. fuscus*.

Pelodytes Fitz.

P. punctatus Daud.—Scapula much reduced, squarish in shape. Shaft shorter than broad at distal end; *pars acromialis* as broad as long, lower border of its outer surface forming a prominent ridge running round the glenoid cavity; *pars glenoidalis* much

Text-figure 7.



Pectoral girdle of *Pelodytes punctatus*. ×2.
(*a*) from without; (*b*) scapula from within.

depressed, subcircular; dividing cleft short, pierced horizontally, only visible when viewed obliquely.

Example.

Length of præcoracoid	10 units.
,, scapula (upper border)	5·6 ,,
,, ,, shaft	4·4 ,,
Breadth of ,, (distal end)	4·4 ,,
Length of supra-scapula (upper edge)	9·4 ,,

In shape the scapula of *Pelodytes* is very similar to that of *Palæobatrachus*, which it resembles in many ways. *Palæobatrachus*, however, lacks the proximal dividing cleft, which, though outwardly invisible, is present in *Pelodytes*.

Batrachopsis Blgr.

B. melanopyga Doria.—Scapula well developed, about once and a quarter as long as præcoracoid; slender in the middle,

distal end broader than proximal. Shaft long, wedge-shaped; *pars acromialis* with straight oblique upper border, upper half of proximal end free; *pars glenoidalis* much depressed, slightly undermining *pars acromialis*; dividing cleft short, pierced horizontally, only visible when viewed obliquely.

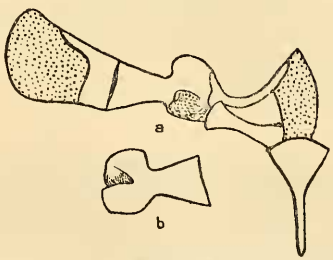
Example.

Length of præcoracoid	.....	10 units.
,, scapula (upper or lower edge)	...	12·2 ,,
,, ,, shaft	.....	9·4 ,,
Breadth of ,, (distal end)	.....	6·1 ,,
,, ,, (middle)	.....	2·5 ,,
,, ,, (proximal end)	.....	5 ,,
Length of supra-scapula	.....	11·6 ,,

Megalophrys Kuhl.

M. pelodytoides Blgr.—Scapula well developed in all its parts, as long as the præcoracoid. Shaft wedge-shaped, as long as broad at distal end; *pars acromialis* with an oblique straight crest along its upper border, rising to a sharp point proximally; lower ridge of outer surface with a prominent ridge running round the glenoid cavity; upper half of proximal end free; *pars glenoidalis* much depressed; dividing cleft short and broad, pierced obliquely, forming a foramen, which is longer when viewed from within than when viewed from without.

Text-figure 8.



Pectoral girdle of *Megalophrys parva*. ×2.
(*a*) from within; (*b*) from without.

Example.

Length of præcoracoid	.....	10 units.
,, scapula	.....	10 ,,
,, ,, shaft	.....	6·2 ,,
Breadth of ,, (distal end)	.....	6·2 ,,
Length of supra-scapula	.....	11·3 ,,

M. major Blgr.—Scapula similar in form to that of *M. pelodytoides* with the exception of the *pars acromialis*, the crest of which has a paracentric upper edge; upper half of proximal end free.

M. parva Blgr. (= *Xenophrys monticola* Gthr.).—Scapula as

in *M. major*. In this species the præcoracoids are reduced, and do not meet each other in the middle; the scapula is, therefore, longer than the præcoracoid, but not longer than its distance from the edge of the epicoracoidal cartilage.

M. montana Kuhl.—Form of scapula as in *M. major*, but slightly larger than the præcoracoid, which is normal in length.

M. longipes Blgr. —Scapula as in *M. major*.

M. fece Blgr.—Form of scapula similar to that of *M. major*, with the exception of the distal end of the shaft, the lower corner of which is somewhat produced, making the lower border of the scapula once and a quarter the length of the upper border; lower border of scapula describing an inverted semicircular curve, ⌒. *Pars acromialis* with a semicircular upper edge.

Although there is specific differentiation within this complex genus, the form of the scapula is highly characteristic. The equal development of the shaft, the *pars acromialis*, and *pars glenoidalis*, together with the oval central foramen, pierced horizontally, and the highly developed crest of the *pars acromialis*, are characters common to all the species.

Hylidæ.

In this family the scapula is usually normal in its proportions, and about equal in length to the præcoracoid. In some instances, however, it is greatly reduced in length, especially the shaft. The cleft between the *pars acromialis* and *pars glenoidalis* is always broad and open, pierced vertically, and visible from without and within as a large oval foramen in the middle of the glenoid cavity. The *pars glenoidalis* is reduced in size, and always shorter than the *pars acromialis*, part of it presumably giving place to the central foramen.

Hyla Laur.

H. maxima Laur.—Scapula normal in its proportions, equal in length to the præcoracoid, and having all the family characteristics already described. Shaft once and a quarter as long as broad at distal end; *pars glenoidalis* separated from coracoid by cartilage; superficial articulation and *fovea acetabulum* very distinct.

Example.

Length of præcoracoid	.....	10 units.
,, scapula (upper border)	.....	10 ,,
,, ,, shaft	.....	9·1 ,,
Breadth of ,, (distal end)	.....	6·4 ,,
,, ,, (middle)	.....	2·7 ,,
,, *pars acromialis*	.....	1·8 ,,
,, *pars glenoidalis*	.....	1·8 ,,
Length of *pars acromialis*	.....	2·7 ,,
,, *pars glenoidalis*	.....	1·8 ,,
,, supra-scapula	.....	11·4 ,,

In the following species the scapula is as in *H. maxima* :— *H. faber* Wied, *H. albomarginata* Spix, *H. boans* Daud., *H. taurina* Fitz., *H. venulosa* Laur., *H. nigromaculata* Tschudi, *H. dominicensis* Bibron, *H. versicolor* Lec., *H. pulchella* D. & B., *H. arborea* L., *H. macrops* Blgr., *H. cærulea* White, *H. dolichopsis* Cope, *H. aurea* Less., *H. lesueurii* D. & B., *H. nasuta* Gray, *H. gratiosa* Lec.

In *H. lichenata* Gosse and *H. baudini* D. & B., the scapula is a little longer than the præcoracoid.

Although *Hyla* is a very large genus, it will be seen that the scapula is remarkably stable in its proportions. It is not of much use, however, as a diagnostic character, as it is of the form most commonly met with in this family.

Nototrema Gthr.

N. marsupiatum D. & B.—Scapula elongated, once and a quarter as long as præcoracoid, very slender in the middle. Shaft as long as præcoracoid; *pars acromialis* and *pars glenoidalis* as in *Hyla maxima*.

Pternohyla Blgr.

P. fodiens Blgr.—Scapula as in *H. maxima*.

Nyctimantis Blgr.

N. papua Blgr.—Scapula as in *H. maxima*.

Agalychnis Cope.

A. moreletii A. Dum.—Scapula as in *H. maxima*.

Phyllomedusa Wagl.

P. dacnicolor Cope.—Scapula abnormally developed, about twice as long as præcoracoid, and about twice and a half as long as broad at distal end. Shaft about once and a quarter as long as præcoracoid, very slender, expanding at distal end; *pars acromialis* not in contact with head of præcoracoid; *pars glenoidalis* very much reduced, branching widely from *pars acromialis*; central foramen very large, oval.

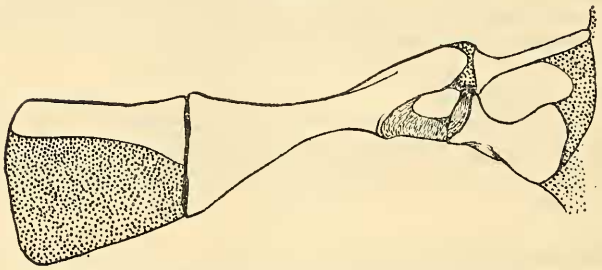
P. bicolor Bodd.—Scapula similar in form to that of *P. dacnicolor*, but even more developed in length, being twice and a quarter the length of the præcoracoid. Shaft once and three-quarters the length of præcoracoid; *pars acromialis* separated from head of præcoracoid on outer surface by acromion cartilage, in contact on inner surface.

Example.

Length of præcoracoid	10	units.
,, scapula (lower border)	23	,,
,, ,, (upper ,,)	24	,,
,, ,, shaft	17	,,

Breadth of scapula (distal end)	10·2	units.
,, ,, (middle)	2·6	,,
,, *pars acromialis*	3·5	,,
,, *pars glenoidalis*	1·7	,,
,, central foramen	2·2	,,
Length of ,, ,,	4·4	,,
,, *pars acromialis*	3·5	,,
,, *pars glenoidalis*	1·7	,,
,, supra-scapula	14·8	,,

Text-figure 9.



Pectoral girdle of *Phyllomedusa bicolor*, ×2; from without.

P. burmeisteri Blgr.—Scapula as in *P. dacnicolor*.

This form of scapula is highly characteristic of the genus *Phyllomedusa*.

Triprion Cope.

T. petasatus Cope.—Scapula as in *Hyla maxima*.

Bufonidæ.

In this family the scapula is usually normal in its proportions; the *pars glenoidalis* is equally developed to the *pars acromialis*. No important variations occur.

Eupemphix Steind.

E. nattereri Steind.—Scapula normal in its proportions; slightly longer than præcoracoid; slender in the middle; similar in shape to that of *Batrachopsis melanopyga*. Dividing cleft between the two *pars* short.

Bufo Laur.

B. vulgaris Laur.—Scapula normal, upper border about as long as præcoracoid, lower border a little longer. Shaft stout, subtriangular; *pars acromialis* somewhat diamond-shaped, with a straight, oblique upper edge; *pars glenoidalis* much depressed, narrower, but equal in length to the *pars acromialis*, from which it branches, forming a Y of which the shafts represent the tail; *pars glenoidalis* widely separated from coracoid by paraglenoid

cartilage; superficial articulation and *fovea acetabulum* strongly marked.

Example.

Length of præcoracoid (greatest)	10	units.
,, scapula (upper border)	10·7	,,
,, ,, (lower ,,)	12·2	,,
,, ,, shaft	7·9	,,
Breadth of ,, (distal end)	7·9	,,
,, ,, (middle)	3·6	,,
,, *pars acromialis*	4·3	,,
,, *pars glenoidalis*	2·15	,,
Length of supra-scapula	12·8	,,

In the following species the scapula is like that of *B. vulgaris*:—*B. hæmatiticus* Cope, *B. calamita* Laur., *B. viridis* Laur., *B. intermedius* Gthr., *B. lentiginosus* Shaw, *B. marinus* L., *B. crucifer* Wied.

In *B. latifrons* Blgr., *B. tuberosus* Gthr., *B. melanostictus* Schn., *B. claviger* Ptrs., *B. quadriporcatus* Blgr., *B. typhonius* L., and *B. valliceps* Wiegm., the scapula is a little longer than the præcoracoid, but of the same form as that of *B. vulgaris*.

In *B. granulosus* Spix the scapula is a little shorter than the præcoracoid.

There is remarkably little variation in this genus, in some species the *pars glenoidalis* is somewhat shorter than in others, and there is slight variation in the length of the shaft.

Example to show Range of Variation in Bufo.

	B. granulosus.	*B. melanostictus.*
Length of præcoracoid	10 units.	10 units.
,, scapula (lower border)	7·7 ,,	14·2 ,,
,, ,, shaft	6·2 ,,	10 ,,
Breadth of ,, (distal end)	6·2 ,,	7·1 ,,
,, ,, (middle)	3·3 ,,	3 ,,
,, *pars acromialis*	4·6 ,,	3 ,,
,, *pars glenoidalis*	3·3 ,,	3 ,,
Length of supra-scapula	10·4 ,,	14·3 ,,

B. melanostictus has been chosen as an example of the more developed type of scapula, as, being a common Malayan form, it forms an interesting comparison with *B. granulosus* from E. South America.

The equal development of the *pars acromialis* and *pars glenoidalis* in length, together with the fact that the latter is always widely separated from the coracoid by cartilage, distinguishes the scapula of *Bufo* from nearly all other genera of the Arcifera (see text-fig. 1).

Rhinophrynus D. & B.

R. dorsalis D. & B.—Scapula as in *Bufo*.

CYSTIGNATHIDÆ.

In this family the scapula is extremely variable. It may be slender or stoutly formed, shorter than the præcoracoid or abnormallly elongated. The range of variation is large as in Hylidæ, and very much greater than in any other families of the Arcifera.

PSEUDIS Laur.

P. paradoxa * L.—Scapula equal in length to the præcoracoid, rather stout, parallelogrammic in shape; superficially similar in shape to that of *Pelodytes punctatus*. Upper border of shaft bearing a thin straight-edged crest; *pars acromialis* broader than long; *pars glenoidalis* narrow, obtusely pointed, partially separated from *pars acromialis* by a notch forming part of a small oval foramen pierced obliquely.

Example.

Length of præcoracoid	10	units.
,, scapula	10	,,
,, ,, shaft	6·7	,,
Breadth of ,, (distal end)	6·7	,,
,, ,, (middle)	6·7	,,
Length of supra-scapula	13·4	,,

CALYPTOCEPHALUS D. & B.

C. gayi D. & B.—Scapula normal in its proportions, but large in comparison with the other bones of the pectoral girdle. Longer than præcoracoid.

TELMATOBIUS Wagl.

T. jelksii Ptrs.—In this species all the bones of the pectoral girdle are extremely stout in comparison with their length. Scapula equal to the præcoracoid in length, stout. Shaft squarish; *pars acromialis* and *pars glenoidalis* both well developed, separated proximally by a very small cleft or central foramen.

Example.

Length of præcoracoid	10	units.
,, scapula (upper border)	10	,,
,, ,, shaft	5·3	,,
Breadth of ,, (distal end)	6·7	,,
,, ,, (middle)	4	,,
,, *pars acromialis*	4·7	,,
,, *pars glenoidalis*	3·3	,,
Length of supra-scapula	12·3	,,

ELOSIA Tsch.

E. bufonia Gir.—Scapula equal to the præcoracoid in length, rather slender, but of normal proportions.

* Bones pale green, as in *Rappia chlorostea* E. Blgr.

Hylodes Fitz.

H. raniformis Blgr.—Scapula a little shorter than the præcoracoid, but well developed. *Pars glenoidalis* smaller than *pars acromialis*; dividing cleft short.

H. fleischmanni Boett.—In this species the scapula is subject to slight individual variation. It may be equal to or a little longer than the præcoracoid.

H. lineatus Schn. and *H. martinicensis* Tsch.—The scapula is as in *H. raniformis*.

The scapula in *Hylodes* is somewhat like that in *Hyla* as regards the relative proportions of the shaft, *pars acromialis*, and *pars glenoidalis*. They differ, however, in that the dividing cleft is short in *Hylodes*, forming a very small central foramen instead of a very large one, as in *Hyla*.

Ceratophrys Boie.

C. boie Wied.—Scapula greatly developed, once and a half as long as præcoracoid. Distal end of shaft about twice width of proximal end; *pars acromialis* and *pars glenoidalis* normal; dividing cleft short, forming a very small central foramen; a small portion of acromion cartilage exposed between head of præcoracoid and end of *pars acromialis*.

In *C. ornata* Bell and *C. americana* D. & B. the scapula is as in *C. boie*.

Example.

Length of præcoracoid	10	units.
,, scapula	15·2	,,
,, ,, shaft	11	,,
Breadth of ,, (distal end)	5	,,
,, ,, (middle)	2·3	,,
Length of supra-scapula	13·7	,,

Leptodactylus Fitz.

L. pentadactylus L.—Scapula equal to or slightly longer than præcoracoid; stoutly formed. Shaft broad, half length of præcoracoid; *pars acromialis* well developed, partially separated from head of præcoracoid by acromion cartilage; *pars glenoidalis* well developed, strongly depressed; dividing cleft short and broad, forming an oval foramen, pierced horizontally, hardly visible from outer view.

L. ocellatus L.—Scapula as in *L. pentadactylus*.

Hylorhina Bell.

H. silvatica Bell.—Scapula as in *Hyla*.

Limnodynastes Fitz.

L. peronii D. & B.—Scapula well developed, longer than præcoracoid; distal end twice the width at the middle. Shaft as long as præcoracoid; *pars acromialis* somewhat diamond-shaped,

having a /\-shaped upper edge; *pars glenoidalis* also well developed; dividing cleft short, forming a small central foramen.

L. dorsalis Gray.—Scapula as in *L. peronii*.

L. ornatus Gray.—Scapula more elongated than in *L. peronii*.

Example.

Length of præcoracoid	10	units.
,, scapula	15	,,
,, ,, shaft	11·6	,,
Breadth of ,, (distal end)	5	,,
,, ,, (middle)	2·5	,,
Length of supra-scapula	15	,,

Cryptotis Gthr.

C. brevis Gthr.—Scapula equal in length to the præcoracoid; normal in its proportions. Dividing cleft pierced horizontally as in *Megalophrys*.

Chiroleptis Gthr.

C. australis Gray.—Scapula greatly developed, about once and three-quarters length of præcoracoid; slender in the middle. Shaft twice as long as broad at distal end, about once and a quarter length of præcoracoid; *pars acromialis* well developed, subtriangular, similar to that of *Bactrachopsis melanopyga*; *pars glenoidalis* smaller than *pars acromialis*; dividing cleft pierced obliquely.

Example.

Length of præcoracoid	10	units.
,, scapula	17	,,
,, ,, shaft	13	,,
Breadth of ,, (distal end)	7	,,
,, ,, (middle)	2	,,
Length of supra-scapula	12(?)	,,

C. platycephalus Gthr.—Scapula similar in form to that of *C. australis*, but much shorter in proportion.

Example.

Length of præcoracoid	10	units.
,, scapula	11·2	,,

Heleioporus Gray.

H. albopunctatus Gray.—Scapula abnormally developed; twice and a half as long as præcoracoid; slender in the middle, greatly expanded at distal end, where it is almost the length of the præcoracoid in width. Shaft once and three-quarters length of præcoracoid; *pars acromialis* well developed, completely in contact with crescentic head of præcoracoid; *pars glenoidalis* also in contact with head of præcoracoid, partially separated

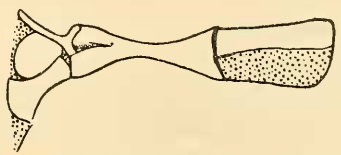
from end of coracoid by cartilage, longer than *pars acromialis*; dividing cleft pierced horizontally, only visible when viewed obliquely.

H. pictus Ptrs.—Scapula as in *H. albopunctatus*.

Example.

Length of præcoracoid	10	units.
,, scapula	25	,,
,, ,, shaft	17·5	,,
Breadth of ,, (distal end)	8·8	,,
,, ,, (middle)	2	,,
,, *pars acromialis* + *pars glenoidalis*	8·8	,,
Length of supra-scapula	17·7	,,

Text-figure 10.



Pectoral girdle of *Heleioporus pictus*, ×2; from within.

The abnormal development of the scapula in this genus is similar to that in *Phyllomedusa* as regards length. In *Phyllomedusa*, however, the *pars glenoidalis* is much smaller than the *pars acromialis*, which is separated from the head of the præcoracoid by acromion cartilage; also the dividing cleft is long and broad, forming a very large central foramen, pierced vertically.

Summary and Conclusion.

These data are sufficient to show that the form of the scapula is remarkably stable within a genus, and that in many instances it is so highly characteristic that a glance at this bone alone suffices to recognize the genus to which the skeleton belongs. This is the case throughout the Pipidæ and Discoglossidæ, and, to a great extent, in other families. In the most recent families, however, there are many genera conforming to one pattern of scapula, which makes the character, in these cases, worthless for diagnostic purposes.

Of the genera which I have studied, the greatest specific variation occurs in *Bufo*; in *Hyla*, which is a very large genus, there is practically none.

Although in many ways the Pelobatid genera resemble *Palæobatrachus*, the Aglossa must be regarded as having the most primitive type of scapula, as in *Pipa*, *Hymenochirus*, and *Xenopus* the proximal end of the bone is entire. In all other genera*

* Genera of the Arcifera.

the *pars acromialis* and *pars glenoidalis* are separated from each other by a cleft, or at least a notch (*Bombinator* and *Pseudis*). This character seems to be of much greater importance than mere size, and corroborates the conclusion of Wolsterstorff, who says* : "*Palæobatrachus* verbindet im Systeme die Aglossa mit den Arcifira."

In spite of generic stability the variation is enormous, particularly in the length of the shaft. *Xenopus*, on the one hand, in which the scapula is absent or represented by the *pars glenoidalis* only, ranging to *Phyllomedusa*, *Ceratophrys*, and *Heleioporus*, in which it is enormously developed, in *Heleioporus* being twice and a half the length of the præcoracoid.

It is astonishing that such a useful bone as the scapula should have been overlooked for so long. The following key is based on this character alone :—

A. Proximal end of scapula entire	Pipidæ.
B. Proximal end of scapula cleft.	
I. Length of scapula ½ or less than ½ length of præcoracoid.	Discoglossidæ.
II. Length of scapula more than ½ length of præcoracoid.	
a. A large oval foramen pierced vertically in glenoid cavity ; *pars glenoidalis* greatly reduced	Hylidæ.
b. Foramen, if pierced vertically in glenoid cavity, moderate or small ; often represented by a cleft pierced obliquely or horizontally	Pelobatidæ. Bufonidæ. Cystignathidæ.

I am unable to find reliable family characteristics which differentiate between the Pelobatidæ, the Bufonidæ, and the Cystignathidæ.

* *Op. cit.*